TECHNICAL BULLETIN

T-015

USE OF GASEOUS FUEL WITH ONAN ELECTRIC PLANTS

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SCOPE

Information in this bulletin applies to natural gas, manufactured (city) gas, and LP (liquefied petroleum) gas. This bulletin is not intended to be an installation manual, but rather a design guide.

The various types of installation problems cannot be all covered because of the variety of requirements. Illustrations of installations are only typical and do not represent actual installations. They do represent recommendations of the manufacturer.

Consult a reputable local gas distributor and NFPA* Pamphlet 58 for more specific information.

EXCERPTS FROM NFPA PAMPHLET 58

It is recommended that the installer or architect read Pamphlet 58.

a. All piping and tubing shall be suitable for a working pressure of not less than 125 psi.

b. Aluminum tubing shall not be used in exterior locations or where it is in contact with masonry, plastered walls, or insulation.

c. No gas in the liquid phase shall be piped into any building for fuel purposes except buildings or separate fire divisions of buildings used exclusively for housing internal combustion engines and for research and experimental laboratories.

e. The use of threaded cast iron pipe fittings is prohibited.

f. Approved flexible hose may be used on the low pressure side of the system.

g. All piping, tubing, and hose shall be tested after assembly and proved free from leaks at not less than normal operating pressures. Tests shall not be made with a flame.

h. Piping outside buildings may be buried, above ground, or both, but shall be well supported and protected against physical damage. Where soil conditions warrant, all piping shall be protected against corrosion. Where condensation may occur, the piping shall be pitched back to the container, or suitable means shall be provided for revaporization of the condensate.

j. Provisions shall be made for expansion, contraction, jarring, vibration and settling. This may be accomplished by flexible connections.

NOTE: *NFPA requires that all standby generating plants be installed in a fireproof room or separate building (see excerpt "C"). Fuel line sizes are determined by individual plant requirements and must include approved shut-off devices.*

*National Fire Prevention Association.

GAS AS A FUEL

Gas is a desirable fuel for internal combustion engines even though there may be a slight loss in power.

Generally gaseous fuels have higher octane ratings than gasoline although some manufactured "city" gases have a poor octane rating. The combustion efficiency of an engine may be increased without producing more heat by increasing the compression ratio. The compression ratio of an engine is limited by the type of fuel used. Generally, natural gas and propane allow using higher compression ratios.

Gaseous fuels have a low residue content and generally build up minimum carbon deposits. Gaseous fuels mix more thoroughly with air to produce a mixture which burns more completely than gasoline mixtures.

Advantages of Gaseous Fuel Operation:

1. Minimum carbon formation.
2. Less sludge in oil.
3. Less valve burning.
4. No wash down of cylinder wall lubrication during engine starting.
5. No tetra-ethyl lead to foul spark plugs and other engine parts.
6. Excellent anti-knock qualities.
7. Small amount of contaminating residues.
8. A more nearly homogeneous mixture in cylinder.

TYPES OF GASEOUS FUELS

The selection of a particular gas for fuel depends on several important factors - (1) availability, (2) efficiency required, (3) engine application (mobile or not), (4) initial cost, and (5) cost of operation.

The amount of heat any fuel is capable of producing depends on the basic structure of the fuel. Dry gases vary in regard to heat content, as does gasoline, diesel fuel, or other fuels. The heat value of a dry gas is usually expressed in BTU/cu. ft. Propane and butane have considerably higher heat values than do methane and ethane.

The amount of heat a given fuel is capable of producing is usually expressed in BTU*. Manufactured gas, composed primarily of methane (marsh gas), has a heat content of about 500 BTU/cu. ft. An engine fueled with this gas would produce about 40% less power than the same engine fueled with gasoline. The heat content of butane, a minor component of LP gas, is about 3260 BTU/cu ft. No derating would be necessary with this fuel. See Power Comparison Table.

*British Thermal Unit.

POWER COMPARISON TABLE

A plant using butane, propane, or a commercial mixture of both will deliver nearly the same power as when using gasoline.

a. Using 1100 BTU gas a plant will deliver 85 to 95 per cent of its gasoline rated power.
b. Using 850 BTU gas a plant will deliver 80 to 85 per cent of its gasoline rated power.
c. Using 600 BTU gas a plant will deliver 70 to 75 per cent of its gasoline rated power.
d. Using 450 BTU gas a plant will deliver 50 to 60 per cent of its gasoline rated power.

Natural gas is composed primarily of methane and varying amounts of other dry gases with a heat content of about 1100-BTU/cu ft. It is piped from the source to points of consumption. In localities situated far from the source, natural gas is comparatively expensive as a fuel. Localities not serviced by natural gas frequently have a manufactured gas system.

Manufactured gas is not greatly adaptable as a fuel for generating plants when efficiency is important because the heat value is so low the engine must be derated as much as 50%. Also, the gas manufacturing cost is usually higher than for other types of fuels. On the other hand, there are no storage problems, such as with LP gas, and ambient temperature has no effect on supplies.

LP gas refers to liquefied petroleum gas, a commercial mixture of propane and butane. The ratio between them varies with local temperatures and user requirements. Propane vaporizes at a lower temperature than butane, while butane has a higher heat content. Stored and transported under pressure in tanks, LP gas at normal temperatures is a vapor. By increasing pressure and lowering the temperature, it remains in a liquefied state until withdrawn from its storage tanks.

TEMPERATURE AND PRESSURE

Temperature and pressure are interdependent. If gas temperature is changed, the pressure will change proportionally. A gas at room temperature can be changed to a liquid by

MAXIMUM POTENTIAL ENGINE CAPABILITY

SPARK IGNITION TYPE					
MODEL*	ADDER**	GASOLINE	PROPANE	NAT. GAS	550 BTU
205LK		2.7	2.5	2.1	1.9
205AJ		2.9	2.8	2.4	2.1
4CCK		6.0	5.8	5.0	4.5
4LKB		4.2	4.1	3.5	3.0
5CCK		6.0	5.8	5.0	4.5
6JB		8.1	7.3	6.6	5.8
705JB		8.1	7.4	6.6	5.9
706JB		8.1	7.4	6.6	5.9
10CCKB		11.1	9.0	7.3	6.4
12JC		16.5	14.9	13.8	12.0
12RJC		17.5	16.0	15.4	13.3
15JC		16.5	14.9	14.3	12.0
15RJC		17.9	16.2	15.6	13.4
30EK		34.8	33.0	29.1	23.1
45EM		49.5	39.9	42.8	32.9
55KB	6.0	67.0	65.0	57.0	49.0
65KB***	6.0	67.0	65.0	57.0	49.0
85KR***	6.0	92.5	85.0	76.5	68.0
115WA***	11.0	120.0	115.0	102.5	98.0
170WB***	17.0	179.0	173.0	162.0	153.0
140WE***	12.0	155.0	150.0	135.0	125.0
150WE***	12.0	155.0	150.0	135.0	125.0

*60-Cycle ratings shown. For 50-cycle plants, use 83 percent of 60 cycle ratings.
**This valve can be added for deducting fan H.P. on city water cooled models.
***These models are available with high compression ratio engines for use on natural gas. When used, the natural gas performance is nearly equal to gasoline engine performance with standard compression ratio except 160WE model which has only 90 percent of gasoline engine output performance.

compression and storage in a closed container. This is how LP gas is liquefied and stored. A liquid at atmospheric pressure can be changed to a gas by raising the temperature to the liquid's boiling point, such as boiling water. If steam from boiling water were piped into a closed container, it would build up pressure within the container. In a like manner LP gas builds pressure within the container.

WORKING PRESSURE

The fuel system components must operate at various working pressures depending on the kind of gas size and length of fuel lines, number of units to be supplied by a given source, ambient temperature, etc. Components must have the strength to function properly under anticipated (or calculated) maximum working pressures. LP gas tanks, for example, must be able to withstand a working pressure of 250-psi as specified in Pamphlet 58, National Fire Protection Association. Regulators must conform to the applicable specifications of the same agency, in addition to performing the functions for which they are designed. The final regulator in a system must be able to maintain a constant pressure within a prescribed range, which may be from 3-ounces to 5-pounds at the inlet.

There are several ways of measuring and expressing pressure. Pressure measured with a manometer is expressed in inches of water or mercury. Pressure measured with a gauge is expressed in ounces or pounds per square inch (psi) Because both systems are used and to convert calculations into like units of measure, refer to the Pressure Equivalent Chart.

PRESSURE EQUIVALENTS

1" Water Column	equals	.58 ounces
11" Water Column	equals	6.38 ounces
11" Water Column	equals	.4 lb./sq. in.
1 lb./sq. in.	equals	27.71" Water Column
1 lb./sq. in.	equals	16 ounces
1 lb./sq. in.	equals	2.04" Mercury
1" Mercury	equals	.49 lb./sq. in.
1 Std. Atmosphere	equals	14.73 lb./sq. in.
1 ounce/sq. in.	equals	1.73" Water Column

N.G 4" WC

FUEL CONSUMPTION AT FULL LOAD IN CU. FT./HR.

MODEL	RPM	HP** GASOLINE	NATURAL GAS	PROPANE*	BUTANE*
07AK	1,800	1.85	28.7	16.7	10.8
1AJ	1,800	2.75	32.9	12.9	10.1
205AJ	3,600	5.5	61.8	24.7	19.3
205LK	1,800	5.0	60	25	20
4LKB	3,600	8.5	-	-	-
4CCK	1,800	10.2	95	40	33
5CCK	1,800	10.2	115	47	37
705JB	1,800	11.9	140	- 63	-
10CCKB	3,600	19.5	200	-	-
12JC	1,800	30.5	228	92	71
12RJC	1,800	33.6	228	92	71
15JC	1,800	30.5	272	110	84
15RJC	1,800	33.6	272	110	84
30EK	1,800	80	475	210	170
45EM	1,800	90	650	295	240
55KB	1,800	120	800	300	232
85KR	1,800	172	1,160	445	345
115WA	1,800	209	1,730	700	540
140WB	1,800	290	2,300	930	720
160WE	1,800	240	1,900	760	600
170WB	1,800	290	2,760	1,110	850

*PROPANE: 1-Gal. = 36.5 Cu. Ft. and 1-LB. = 8.5 Cu. Ft.
BUTANE: 1-Gal. = 31 Cu. Ft. and 1-LB. = 6.5 Cu. Ft.

**Maximum H.P. rating of engine with gasoline fuel. Water Cooled models H.P. rating is the bare engine only. Power required by accessories (cooling fan, battery charging generator, etc.) must be deducted from H.P. rating.

SYSTEM COMPONENTS

Components depend on individual requirements, usually the following components are standard:

Regulators: Gaseous fuel is metered to the carburetor on a demand basis. A regulator (demand or secondary type) is supplied with fuel at an inlet pressure only slightly above atmospheric pressure. If supply pressures are high, (above 6-oz), an additional primary regulator is used to reduce the supply pressure to a suitable level. Two primary regulators used in series are referred to as two stage regulation system.

The demand regulator in most systems regulates the gas flow by responding to pressure changes in the intake system of the engine. When the engine is shut down and there is no demand for fuel, the regulator prevents gas from leaking through to the engine. This type of lock off is usually inadequate and most systems use an electric shut-off valve just before the secondary regulator to provide a more positive method.

Regulators are not always separate units. They may be integrated with a vaporizer or carburetor, but their function remains the same. A separate regulator must never be used between the tank and heat exchanger in a liquid withdrawal system.

Regulators are designed to do a particular job in a particular system. A regulator designed for use in a vapor gas system cannot be used in a liquid gas system without modification. Regulators should be mounted where they will receive least vibration. They should not be in areas of extreme heat.

On late model systems using IMPCO gaseous fuel carburetors, the recommended pressure to the carburetor is 3 oz. A THERMAC regulator is installed at the carburetor as standard equipment to regulate this pressure. The THERMAC regulator is suitable for pressures up to 8 oz. For higher supply pressures, see Regulator Selection chart according to source pressure.

REGULATOR SELECTION

SERIES	IF SOURCE PRESSURE IS: 6 to 16 oz.	1 to 2 lbs.	2 to 4 lbs.	4 lbs. or over
AK, AJ, LK, LKB	I	I	I	I
CCK, JB, CCKB	VI	VI	VI	I
JC, RJC	VI	VI	VI	II
*EK	III	III	III	II
*EM	IV	III	III	II
*KB	IV	IV	IV	III
*KR	IV	IV	IV	IV
*WA, WB, WE	VII	IV	IV	IV

Code numbers refer to KEY column in Regulator Table for regulator part number and identification.

*Thermac regulator standard on EK-EM-KB-KR-WA, WB, WE gas fuel IMPCO system (Max. supply pressure to Thermac is 12 oz. Thermac outlet pressure is 3 oz.)

INLET PRESSURE TO SECONDARY REGULATOR
(Straight Gaseous Fuel Only)

UNIT	PRES.	UNIT	PRES.	UNIT	PRES.*	UNIT	PRES.*
AJ-AK CCK JB,JC RJC (SPEC. P)	2 oz. to 6 oz.	JC RJC (TO SPEC. P) EC-EF	6-oz. to 5-psi	EK EM	12 oz. max. (to Thermac.)	KB-KR WA-WB WE	12 oz. max. (to Thermac)

*Also see combination Fuel section for pressure requirements.

N.G. 4" WC = 2.3 OZ / III

PRIMARY VAPOROUS FUEL REGULATORS

Part Number	Function	Orifice	Inlet Size	Outlet Size	Inlet Pressure	Outlet Pressure	Maximum Capacity	Key
148P33	pressure reducing	9/64"	1/4"	1/2"	250 lbs	11"wc	190 cfh	I
148P34	pressure reducing	1/4"	3/4"	3/4"	200 lbs	11"wc	680 cfh	II
148P343	pressure reducing	1/2"	1-1/4"	1-1/4"	35 lbs	11"wc	1800 cfh	III
148P363	pressure reducing	1"	1-1/2"	1-1/2"	25 lbs	11"wc	7750 cfh	IV
148P427	pressure reducing	3/8"	1"	1"	200 lbs	10lbs	26,600 cfh	V
148P523	pressure reducing	1/4"	1/2"	3/4"	200 lbs	11"wc	330 cfh	VI
148P605	pressure reducing	2"	2"	2"	5 lbs	11"wc	35,600 cfh	VII

Heat Exchangers, Converters, and Vaporizers: These components used only in LP gas liquid withdrawal systems, provide heat for vaporizing liquefied fuel.

Heat is usually supplied by the engine coolant, thermostatically controlled at about 170°F., maintaining a rather constant fuel temperature. This positive method of vaporizing liquefied fuel allows a constant fuel-air mixture despite changes in withdrawal rates and atmospheric temperature.

IMPORTANT: *Where ambient temperatures fall below freezing, generator sets of 50KW and higher capacity should employ a vaporizer which has a gas fueled burner to supply heat for vaporization. An adequate supply of vaporized fuel will thus be assured for starting and permitting the set to immediately carry the load.*

A burner-type vaporizer must be installed outdoors and as close as permissible to the point of consumption. It may be used with either surface or sub-surface tanks. The rate of vaporization is automatically controlled to meet vapor demands. Generated gas, storage gas, or both may be supplied on demand. An anti-overflow valve presents liquid fuel from reaching the service line (See Fig. E).

The capacity of a vaporizer is defined in terms of rate of flow and volume of water, horsepower it serves, the volume of gas it is capable of vaporizing, etc. A vaporizer should have a 20% reserve capacity for peak load operation.

The flow of water through the vaporizer must be great enough to vaporize enough fuel for peak demands. If water lines are obstructed or too small, so much heat will be taken from the water that it will actually freeze. Moreover, if the fuel mixture becomes too lean, efficiency is lost and engine valves may become susceptible to burning. Not only does this apply to vaporizers, but to the size of fuel tanks in vapor withdrawal systems as well. May vaporizers have the primary and secondary regulator built into them.

Fuel Strainer: Foreign substances can cause failure of sensitive components in gaseous fuel systems. Natural gas contains a gummy substance with a sulfur base which is one of the chief contaminants. Rust, scale, etc., eventually find their way into the fuel system and damage valves and and orifices.

Moisture, usually present to some degree, must be eliminated or freezing may occur at the regulators or carburetor during peak loads. Mount the filter slightly lower than the regulator, between the tank and first system component (Refer to typical installation illustrations).

FUEL STRAINERS

PART NUMBER	PIPE SIZE	TYPE	TYPE OF FUEL
149P558	3/4"	"Y"	Natural or LP Gas Vapor
149P624	1-1/4"	"Y"	Natural
149P625	1/4"	CONE	LP Gas Liquid
149P751	2"	"Y"	Natural
149P752	1"	"Y"	Natural

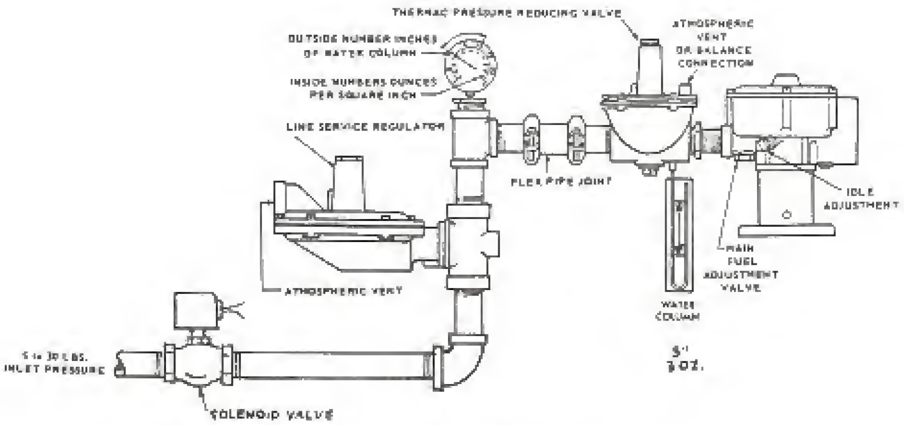
Electric Shut-Off Valve: Most installations use an electric fuel shut-off (solenoid valve) which shuts off the gas supply when the engine is stopped. Check applicable agency code requirements for electric lock-off valves for protection against potential fire hazards.

The final regulator in some instances is an acceptable shut-off valve, but a more positive lock off is usually desired and may be required. See Electric Shut-off Valve and Shut-off Valve Selection Tables for characteristics and usage.

ELECTRIC SHUT-OFF VALVES

SHUT-OFF VALVE SELECTION

MODEL OR SIZE PLANT	SYSTEM PRESSURE	12-VOLT	24-VOLT	36-VOLT	VAPOR MAX PRESS	PIPE SIZE
15-KW and Smaller	Under 8-ounces	307P312		307P387	8	3/4"
15-KW and Smaller	1/2 to 25 Pounds	307A834	307A863	307A868	25	3/4"
EC, EF, EK, EM		307A836	307A865	307A870	25	1"
KB, KR, WC, KT		307A837	307A866	307A838	25	1-1/4"
WA, WB, WE	1 to 5 Pounds	307A840	307A841	307A842	15	2"
LIQUID FUEL		307P268		307P366	150	1/4"



TYPICAL IMPCO GAS FUEL SYSTEM

VAPOR WITHDRAWAL

LP gas vapor withdrawn from the tank for consumption carries away a certain amount of heat from the liquid. This heat loss causes the temperature and pressure of the liquid within the tank to fall. Heat is normally absorbed thru the tank wall to replace the lost heat. If heat can be replaced, the system will function as intended. If fuel consumption is high and ambient temperatures are low, or either extreme, so much heat is lost that it cannot be replaced from around the tank, and the system will not function efficiently.

There are two methods to assist heat transfer (tanks in vapor withdrawal systems absorb heat through only the portion which is in direct contact with the liquefied gas):

1. Use a suitable vaporizer for positive vaporization (liquid withdrawal).
2. Use a tank large enough to meet peak engine demands.

Surface and Sub-Surface LP Gas Tanks: Select and size the LP gas tanks according to the following requirements.

1. Type of withdrawal system.
2. Atmospheric (or design) temperature.
3. Vaporization characteristics of fuel.
4. Consumption.

LP gas temperature is critically important and imposes several limitations. Full power cannot be obtained from plants fueled by vapor withdrawal systems in which the fuel tanks are too small for the prevailing temperature. In many cases, it may be less expensive to purchase a vaporizer for positive vaporization than to purchase a larger tank to merely provide a greater area for heat transfer.

Burying tanks below frost line, where the temperature never goes below 35°F, is all right if adequate allowances are made for year to year variation. In northern climates the frost line might be 4-feet one year and 8-feet the next year, depending on snow cover, etc.

Following are some representative figures for tanks buried at least 2 feet below the frost line when used in vapor withdrawal systems: a 500-gallon tank half full will vaporize 8-1/2 gallons per hour (300 cu ft/hr at 40°F, and a 1000 gallon tank half full will vaporize 15 gallons per hour (540 cu ft/hr) at 40°F.

The following four tables apply only to propane, the major component of LP gas. The vaporization rates are based on the average temperature over an 8-hour period. The column temperatures heading represent the lowest average winter temperature, which is the average of the daily winter low temperatures. Use the table which pertains to the type of container to be used.

PROPANE
NO. OF 20-GALLON CYLINDERS REQUIRED AT THE VARIOUS INDICATED TEMPERATURES WHEN KEPT AT LEAST 1/2 FULL

WITHDRAWAL RATE	32°F.	20°F.	10°F.	0°F.	-10°F.	-20°F.	-30°F.
		LOWEST AVERAGE WINTER TEMPERATURE					
10 CFH-25,000 BTU/Hr.	1	1	1	1	1	1	2
25 CFH-62,500 BTU/Hr.	1	1	1	2	2	3	4
50 CFH-125,000 BTU/Hr.	2	2	3	3	4	5	9
100 CFH-250,000 BTU/Hr.	4	4	5	6	7	10	20

Determining Number of 20-Gallon Cylinders Required: Assume that a model 5CCK-1R plant is to be installed using Propane gas. The lowest average outdoor temperature is found to be -10°F. No other gas appliances will be used.

1. Refer to Fuel Consumption table. Note that a series CCK uses approximately 50-cu.ft. of fuel per hour at full rated load.
2. Refer to Cylinders Required table. Note that at -10°F., 4-cylinders will provide 50-cu.ft. of vapor fuel per hour. This will be sufficient for plant operation.

PROPANE
SIZE OF TANK REQUIRED AT THE VARIOUS INDICATED TEMPERATURES WHEN KEPT AT LEAST 1/2 FULL

WITHDRAWAL RATE	LOWEST AVERAGE WINTER TEMPERATURE						
	32°F.	20°F	10°F	0°F.	-10°F.	-20°F.	-30°F
50 CFH-125,000 BTU/Hr.	115 Gal.	115 Gal.	115 Gal.	250 Gal.	250 Gal.	400 Gal.	600 Gal.
100 CFH-250,000 BTU/Hr.	250 Gal.	250 Gal.	250 Gal.	400 Gal.	500 Gal.	1000 Gal.	1500 Gal.
150 CFH-375,000 BTU/Hr.	300 Gal.	400 Gal.	500 Gal.	500 Gal.	1000 Gal.	1500 Gal.	2500 Gal.
200 CFH-500,000 BTU/Hr.	400 Gal.	500 Gal.	750 Gal.	1000 Gal.	1200 Gal.	2000 Gal.	3500 Gal.
300 CFH-750,000 BTU/Hr.	750 Gal.	1000 Gal.	1500 Gal.	2000 Gal.	2500 Gal.	4000 Gal.	5000 Gal.

LPG VAPOR - TWO STAGE (2-regulators) REGULATION
(5-15 LBS., ALLOWING PRESSURE DROP OF 1-PSI)
DIAMETER OF FUEL LINE IN INCHES FOR THE VARIOUS LENGTHS OF PIPE

PLANT	KW	C.F.H.	15'	25'	50'	75'	100'	150'	200'	300'
AJ	1	15★	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*
LK	2.5	25	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*
CCK	4	40	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	3/8#	3/8#
CCK	5	50	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	3/8#	3/8#
JB	7.5	65	1/4*	1/4*	3/8#	3/8#	3/8#	3/8#	3/8#	3/8#
JC	12	138	3/8#	3/8#	3/8#	1/2†	1/2†	1/2†	1/2†	1/2†
EC	30	195	3/8#	3/8#	1/2†	1/2†	1/2†	1/2	1/2	3/4
EM	45	290	3/8#	1/2†	1/2†	1/2	1/2	3/4	3/4	3/4
EF	45	280	3/8#	1/2†	1/2†	1/2	1/2	3/4	3/4	3/4
EK	30	210	3/8#	3/8#	1/2†	1/2†	1/2	1/2	1/2	3/4
KB	50	303	1/2†	1/2†	1/2†	1/2	1/2	3/4	3/4	3/4
KB	60	350	1/2†	1/2†	1/2	1/2	3/4	3/4	3/4	3/4
KR	85	445	1/2	1/2	/4	3/4	1	1	1	1 1/4
WA	115	700	1/2	3/4	3/4	1	1	1	1	1 1/4
WB	140	930	3/4	3/4	1	1	1	1 1/4	1 1/4	1 1/4
WE	160	760	---	---	---	---	---	---	---	---
WB	170	1, 110	3/4	3/4	1	1	1 1/4	1 1/4	1 1/4	1 1/4

* - 3/8 o.d. tubing may be used
# – 1/2 o.d. tubing may be used
† - 5/8 o.d. tubing may be used

LPG VAPOR - 11" WATER COLUMN, 0.5" PRESSURE DROP
DIAMETER OF FUEL LINE IN INCHES FOR THE VARIOUS LENGTHS OF PIPE

PLANT	KW	C.F.H.	15'	25'	50'	75'	100'	150'	200'	300'
AJ	1	15★	1/2*	1/2*	1/2*	1/2#	1/2#	1/2†	1/2†	3/4†
LK	2.5	25	1/2**	1/2**	1/2**	1/2#	1/2#	3/4#	3/4	3/4
CCK	4	40	1/2#	1/2†	3/4†	3/4†	3/4	3/4	1	1
CCK	5	50	3/4#	3/4†	3/4†	1	1	1	1	1 1/4
JB	7.5	65	3/4†	3/4†	3/4	1	1	1	1 1/4	1 1/4
JC	12	138	3/4	1	1	1	1 1/4	1 1/4	1 1/2	1 1/2
EC	30	195	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2
EM	45	290	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	2	2
EF	45	280	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	2	2
EK	30	210	1	1	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2
KB	50	303	1	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2
KB	60	350	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2
KR	85	445	1 1/2	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2
WA	115	700	1 1/2	2	2	2	2	2 1/2	2 1/2	2 1/2
WB	140	930	1 1/2	2	2	2 1/2	2 1/2	2 1/2	2 1/2	3

Never use smaller than 1/2 o.d. tubing
* - 1/2 o.d. tubing may be used
# - 5/8 o.d. tubing may be used
† - 3/4 o.d. tubing may be used

NATURAL GAS - 11" WATER COLUMN, 0.5" PRESSURE DROP
DIAMETER OF FUEL LINE IN INCHES FOR THE VARIOUS LENGTHS OF PIPE

PLANT	KW	C.F.H.	15'	25'	50'	75'	100'	150'	200'	300'
AJ	1	30★	1/2	1/2	1/2	3/4	3/4	3/4	1	1 1/4
LK	2	60	1/2	3/4	3/4	3/4	3/4	1	1	1 1/4
CCK	4	85	3/4	3/4	3/4	1	1	1	1 1/4	1 1/4
CCK	5	108	3/4	3/4	1	1	1	1 1/4	1 1/4	1 1/4
JB	7.5	108	3/4	3/4	1	1	1	1 1/4	1 1/4	1 1/4
JC	12	228	1	1 1/4	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2
EC	30	480	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2
EK	30	475	1 1/4	1 1/4	1 1/2	1 1/2	1 1/2	2	2	2
EM	45	650	1 1/4	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2
EF	45	700	1 1/4	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2
KB	55	800	1 1/2	1 1/2	2	2	2	2 1/2	2 1/2	2 1/2
KR	85	1,160	2	2	2	2	2 1/2	2 1/2	2 1/2	3
WA	115	1,730	2	2 1/2	2 1/2	3	3	3	3 1/2	3 1/2
WB	140	2,300	2	2 1/2	3	3	3	3 1/2	3 1/2	3 1/2
WE	150	1,900	2	2 1/2	2 1/2	3	3	3	3 1/2	3 1/2
WB	170	2,760	2 1/2	2 1/2	3	3	3 1/2	3 1/2	3 1/2	4

Allowance has been made for a nominal number of fittings.
★ - These values are only representative; refer to page 5 for specific values.

Combination Gaseous Fuel and Gasoline Systems: The combination fuel system can use either a gaseous fuel or gasoline to run the generating plant. Conversion from one fuel to the other usually consists of shutting off one fuel supply and allowing the other fuel to flow to the carburetor. Most combination carburetors contain fuel shut-off valves and float locking devices for simple conversion. Idle and power adjustments for either fuel are also included in the carburetor for ease of maintenance. Refer to the Plant Operator Manuals and Technical Bulletin T014 for installation techniques.

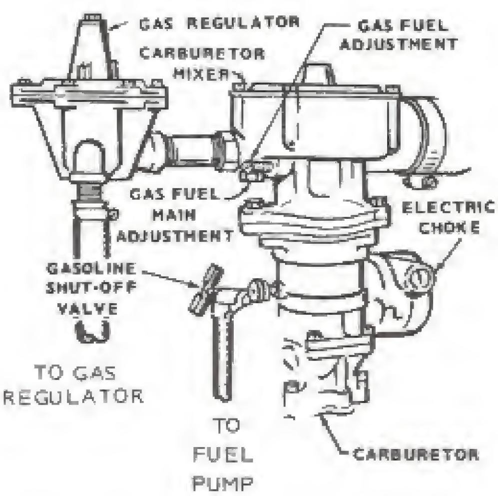
Gasoline supply lines and tanks are conventionally designed, installed, and serviced as on straight gasoline fuel plants. The gaseous fuel (Nat. gas, LPG) installation is essentially the same as on straight gas fuel plants. The selection of valves, regulators, filter, and other components is the same as in the preceding sections of this bulletin with the exception of the following inlet pressure differences.

FUEL LINE SIZE

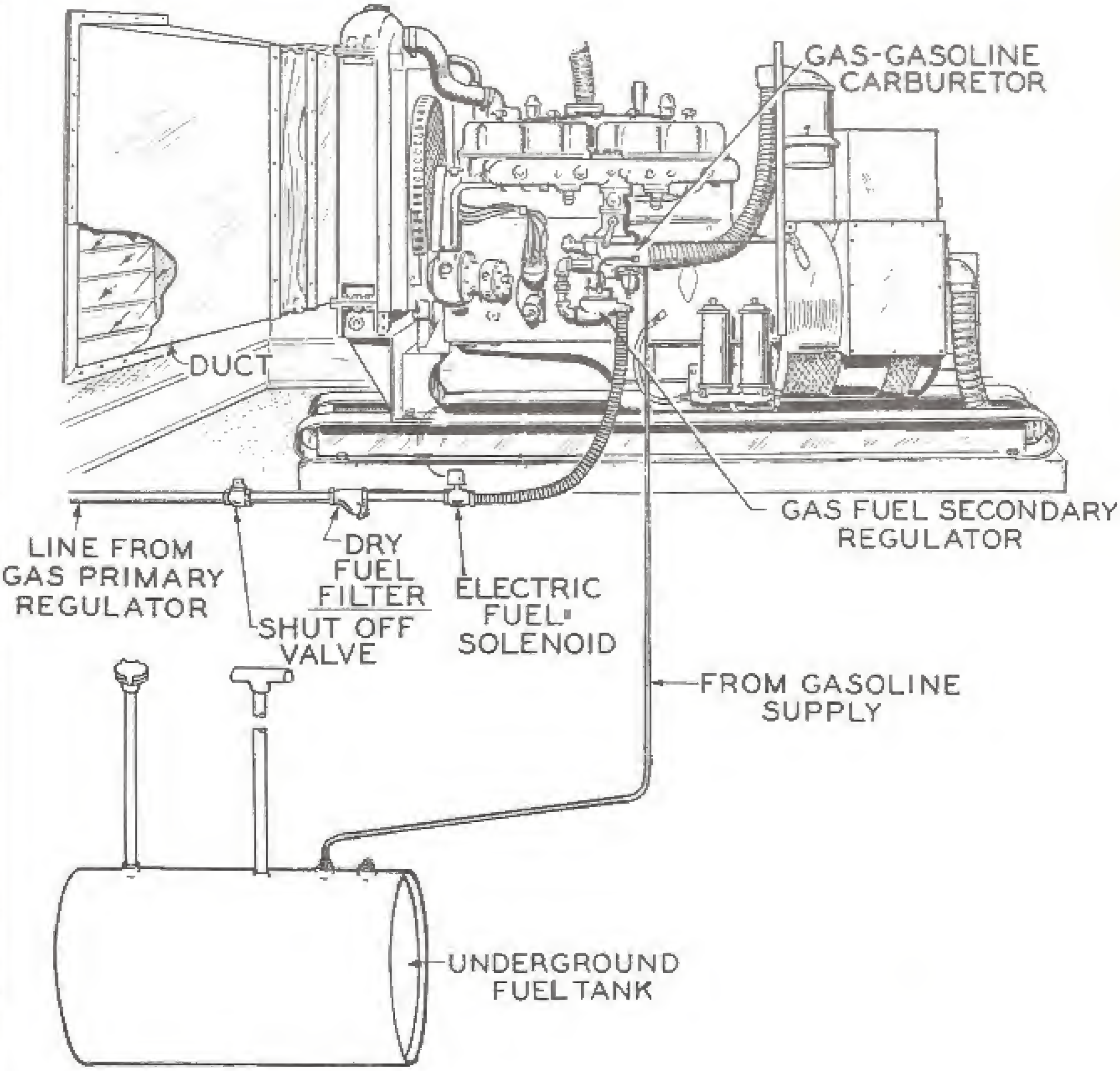
Fuel line size depends on the amount of fuel needed to run a plant at full load and the distance the fuel must be moved. The Fuel Line Tables contain this information. A reserve factor is taken into account.

INLET PRESSURE TO SECONDARY REGULATOR (Combination Fuel)
OR THERMAC REGULATOR

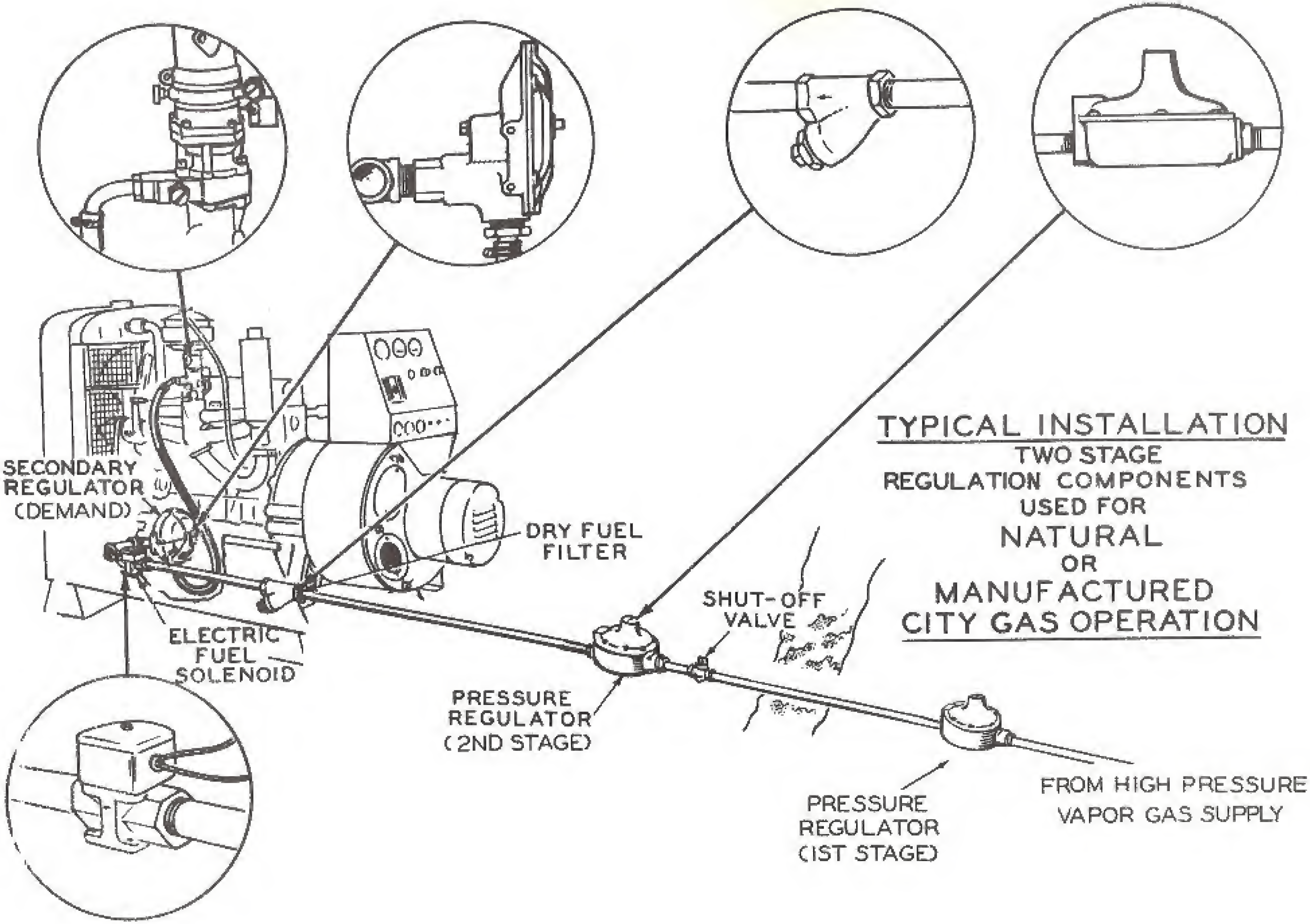
UNIT	PRES.
EK, EM WA,WB WE	6-oz.
KB, KR	4 to 6 oz.

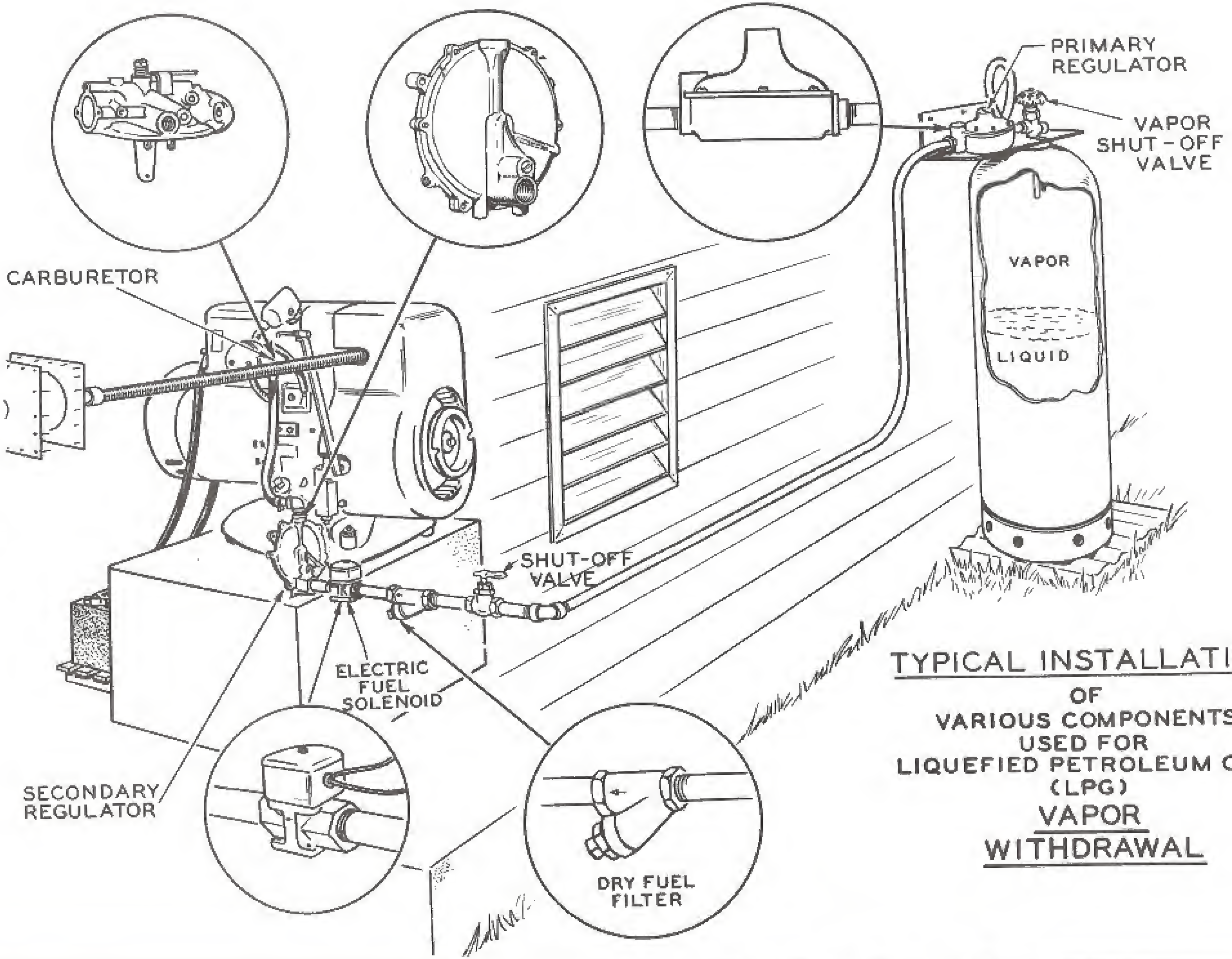


TYPICAL COMBINATION FUEL SYSTEM

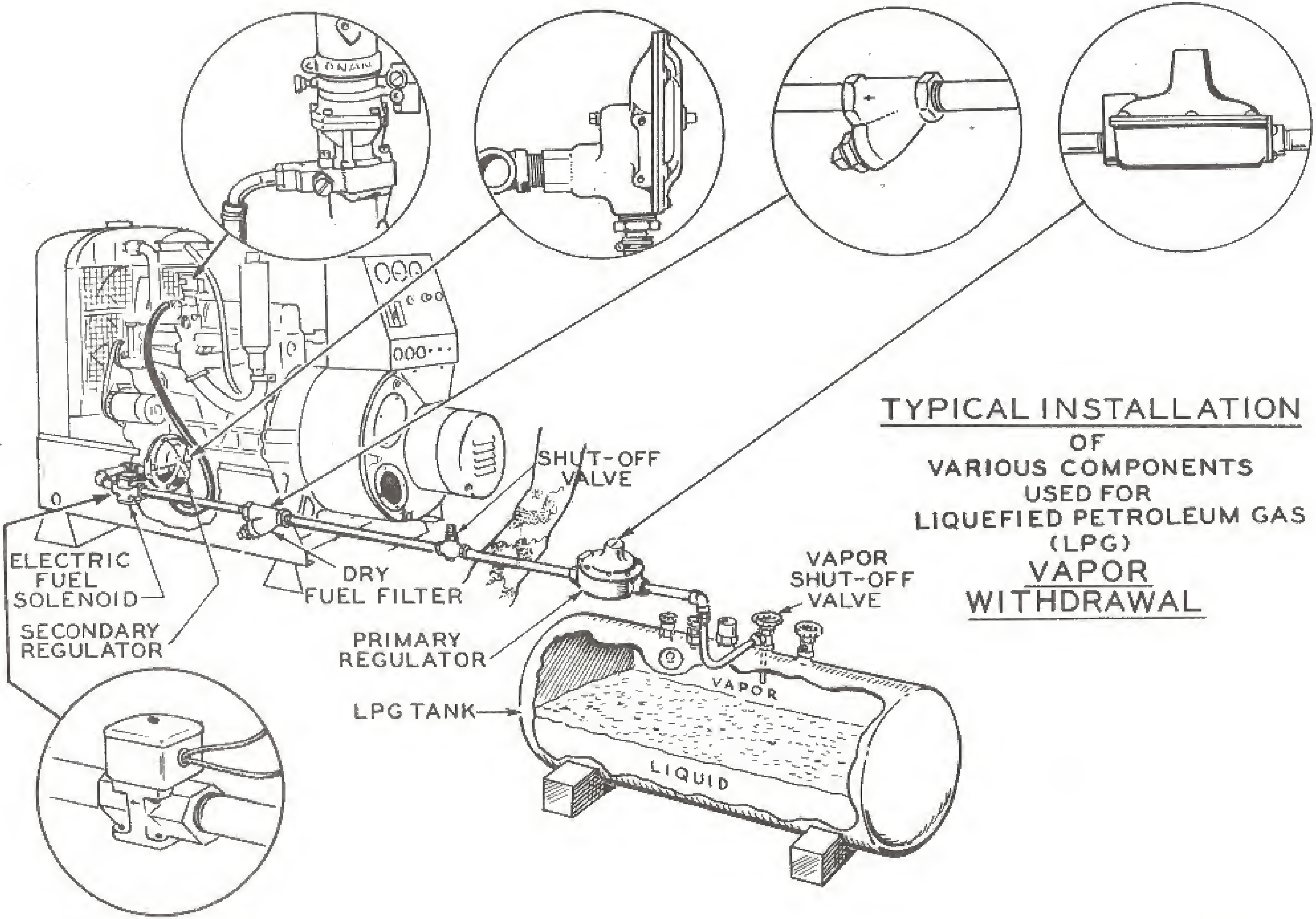


TYPICAL INSTALLATION
GAS-GASOLINE FUEL

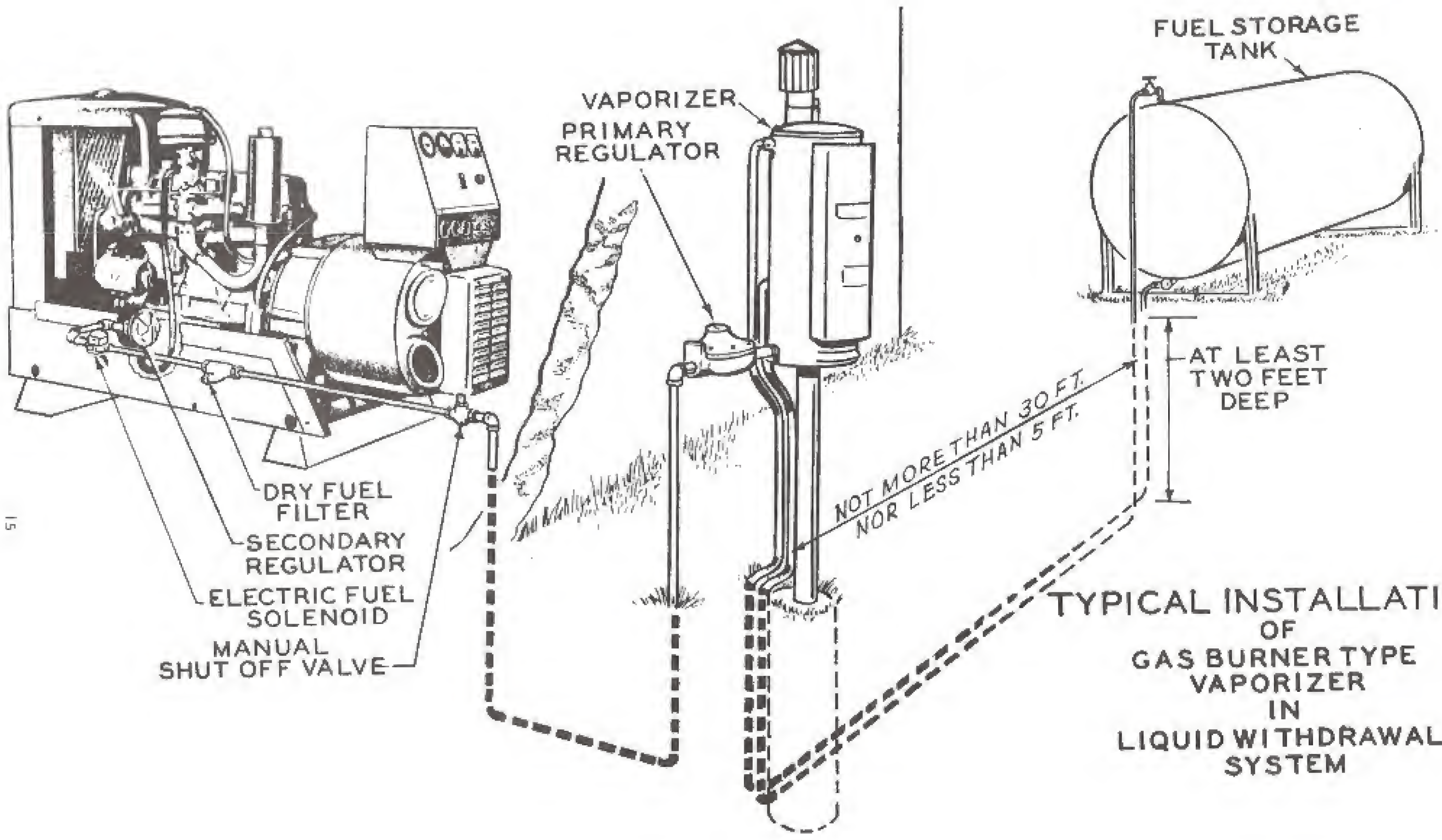

TYPICAL INSTALLATION
TWO STAGE
REGULATION COMPONENTS
USED FOR
NATURAL
OR
MANUFACTURED
CITY GAS OPERATION
SECONDARY
REGULATOR
(DEMAND)
DRY FUEL
FILTER
ELECTRIC
FUEL
SOLENOID
SHUT-OFF
VALVE
PRESSURE
REGULATOR
(2ND STAGE)
PRESSURE
REGULATOR
(1ST STAGE)
FROM HIGH PRESSURE
VAPOR GAS SUPPLY



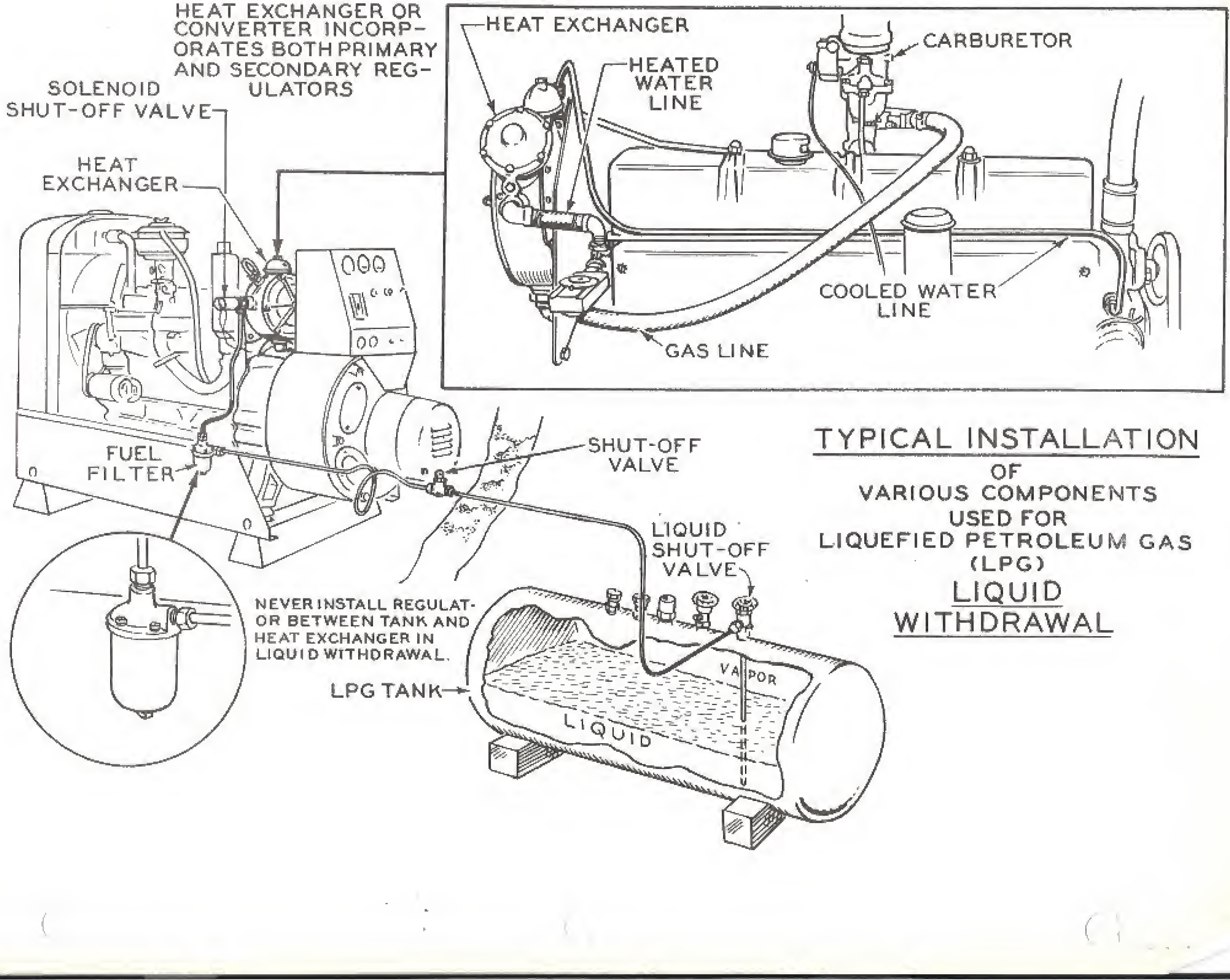
TYPICAL INSTALLATION
OF
VARIOUS COMPONENTS
USED FOR
LIQUEFIED PETROLEUM GAS
(LPG)
VAPOR
WITHDRAWAL



TYPICAL INSTALLATION OF VARIOUS COMPONENTS USED FOR LIQUEFIED PETROLEUM GAS (LPG) VAPOR WITHDRAWAL



TYPICAL INSTALLATION
OF
GAS BURNER TYPE
VAPORIZER
IN
LIQUID WITHDRAWAL
SYSTEM



TYPICAL INSTALLATION
OF
VARIOUS COMPONENTS
USED FOR
LIQUEFIED PETROLEUM GAS
(LPG)
LIQUID
WITHDRAWAL